WD 08: CBM-A

Intelligent Vehicle Health Management System (IVHMS) for Light Tactical Vehicles

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Presentation Outline

- Project Objectives and Overview
- Axle and Engine Vehicle Sensors
- Electronics Module Description
- Fuzzy Model for Diagnostics and Prognostics

Objectives

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Project

- Develop a vehicle health management system for quick installation on vehicles without existing electronic sensor networks, e.g. CAN-Bus.
- Identify a comprehensive vehicle-condition sensor array along with its wireless connection
- Develop vehicle on-board sensor data storage unit and secure sensor data transmission unit
- Develop algorithms for depot on-site diagnostics and prognostics
- Develop vehicle on-board maintenance warning capability

Long Term

- Significantly reduce maintenance cost through CBM for Army's current Light Tactical Vehicle Fleet
- Potentially save solders' lives by not allowing vehicles in need of maintenance to be deployed

System Architecture

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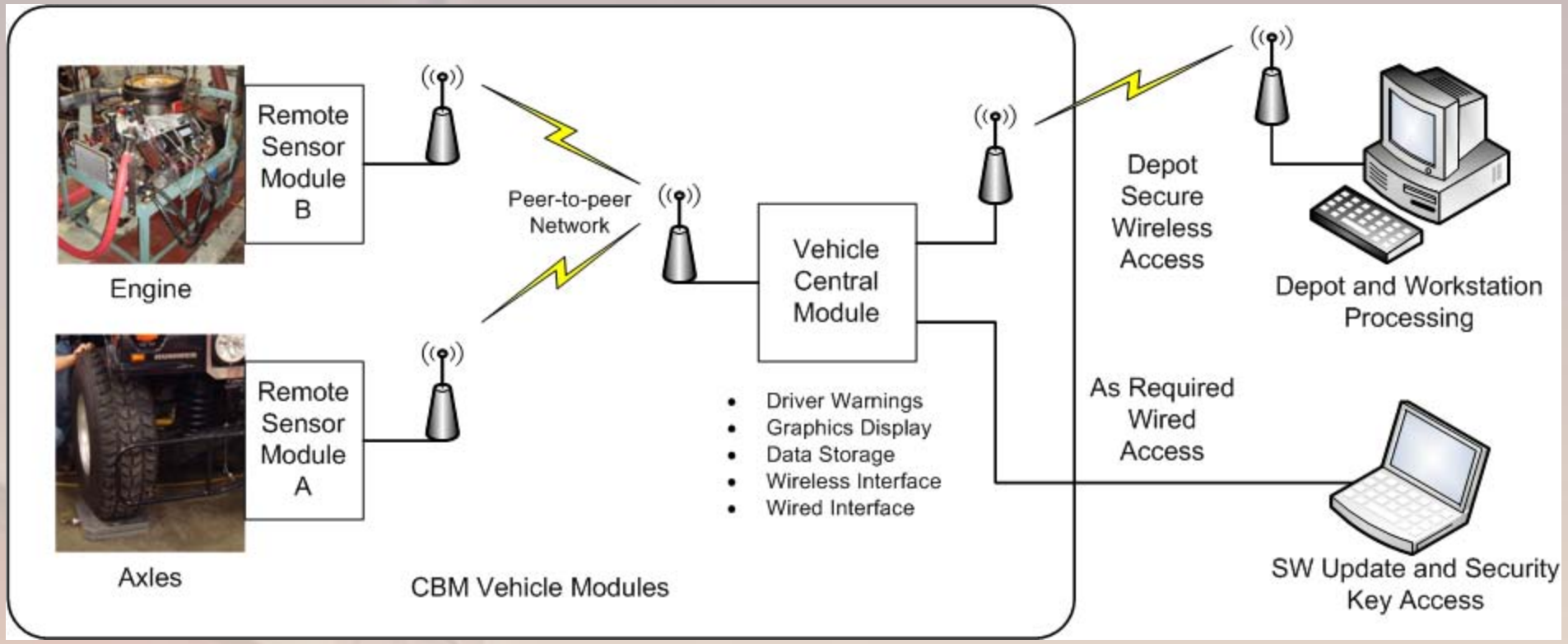

Workstation Software Development

- Fuzzy algorithm development for vehicle diagnostics and prognostics.
- Vehicle warning algorithm to be determined

Axle Sensors

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WMU In-house Test Vehicle

Dr. Richard Hathaway

Axle Measurements

- Strain Gages - Wheatstone Bridge
- Thermocouple Temperatures

WMU 1995 Hummer Work

- Static measurements and calculations completed
  - Weight, weight distribution, CG, tire characteristics, suspension, etc.
- Strain gage and thermocouple mounting in process
  - Gage calibration

Engine Sensors

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Dr. Claudia Fajardo

Engine Measurements

- Throttle Position
- Crankshaft Rotational Speed
- Thermocouple Temperatures
  - Inlet, exhaust, 8 cylinders
- Differential Pressure
- Torque

WMU Engine Test Facility

Microcontrolled Wireless Sensor

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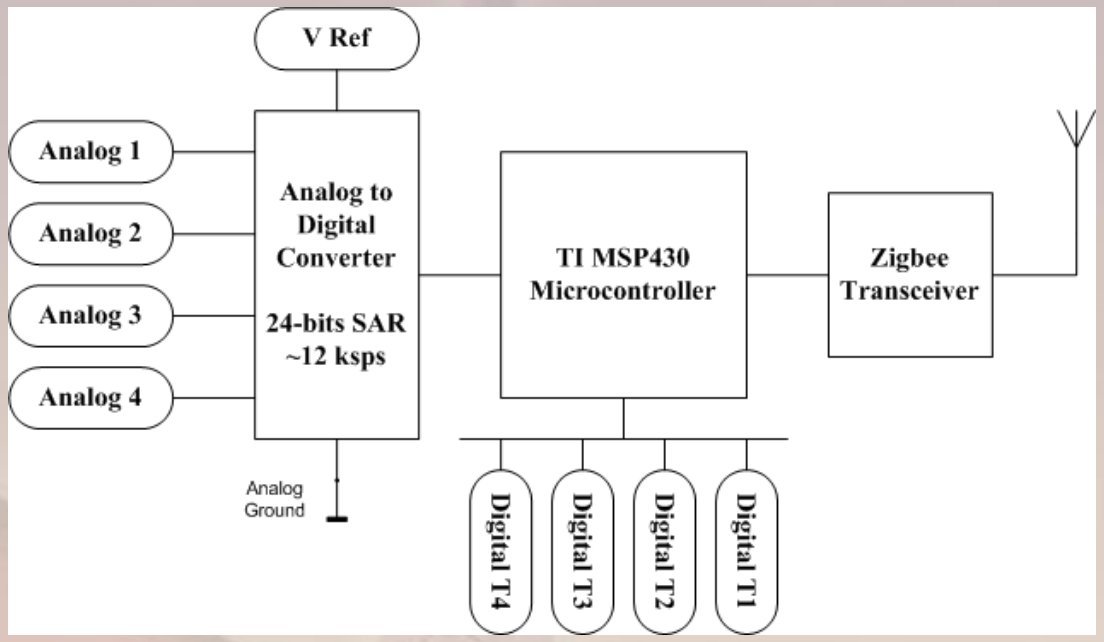

- 24-bit 4 channel SAR Analog to Digital Converter
  - Precision Voltage Reference
  - Per channel compensation available
- TI MSP430 Microcontroller
  - Low standby power
  - TI or GCC development tools available
- Zigbee RF
  - PCB antenna
  - 2.4 GHz ISM

Custom Sensor PCB

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- In-house PCB layout and assembly
  - ORCAD layout tools
  - Vendor PCB fab
  - Solder Paste Stencil
  - Reflow Oven
  - Rework station and tools

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Central Module

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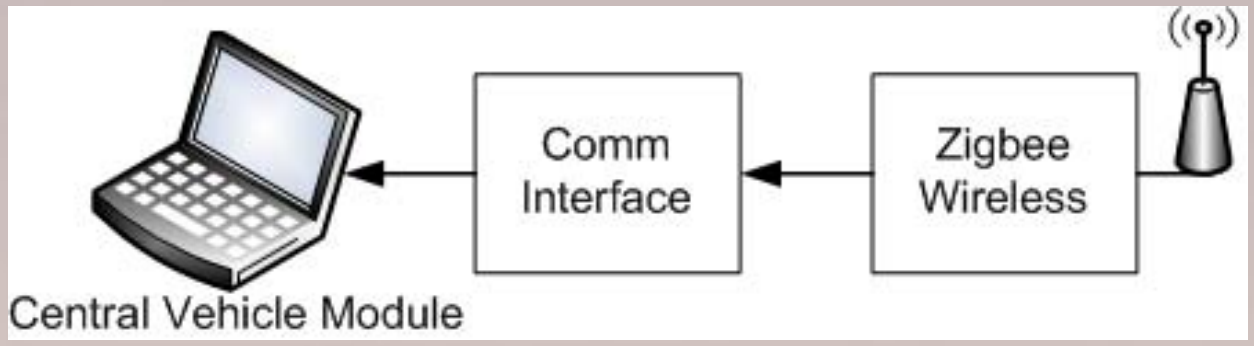
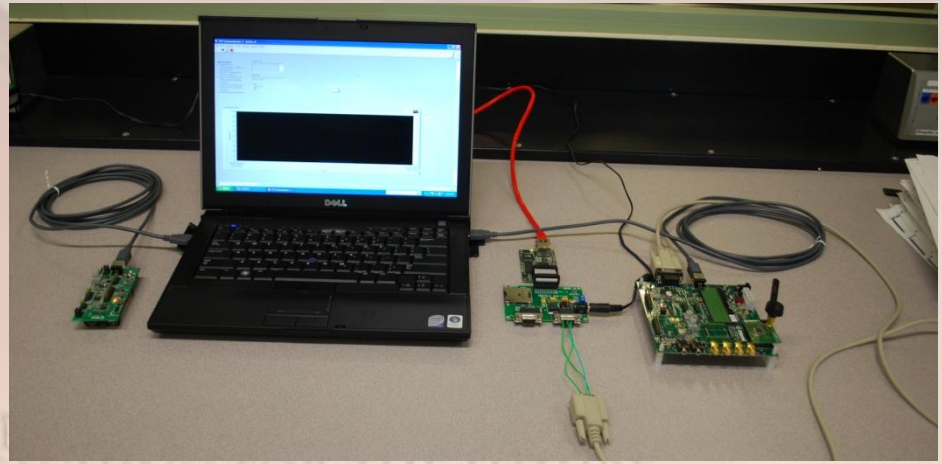
Design Tradeoff:

- Laptop provides a majority of module requirements
- Minimize custom PCB design and risk.





Zigbee Testing

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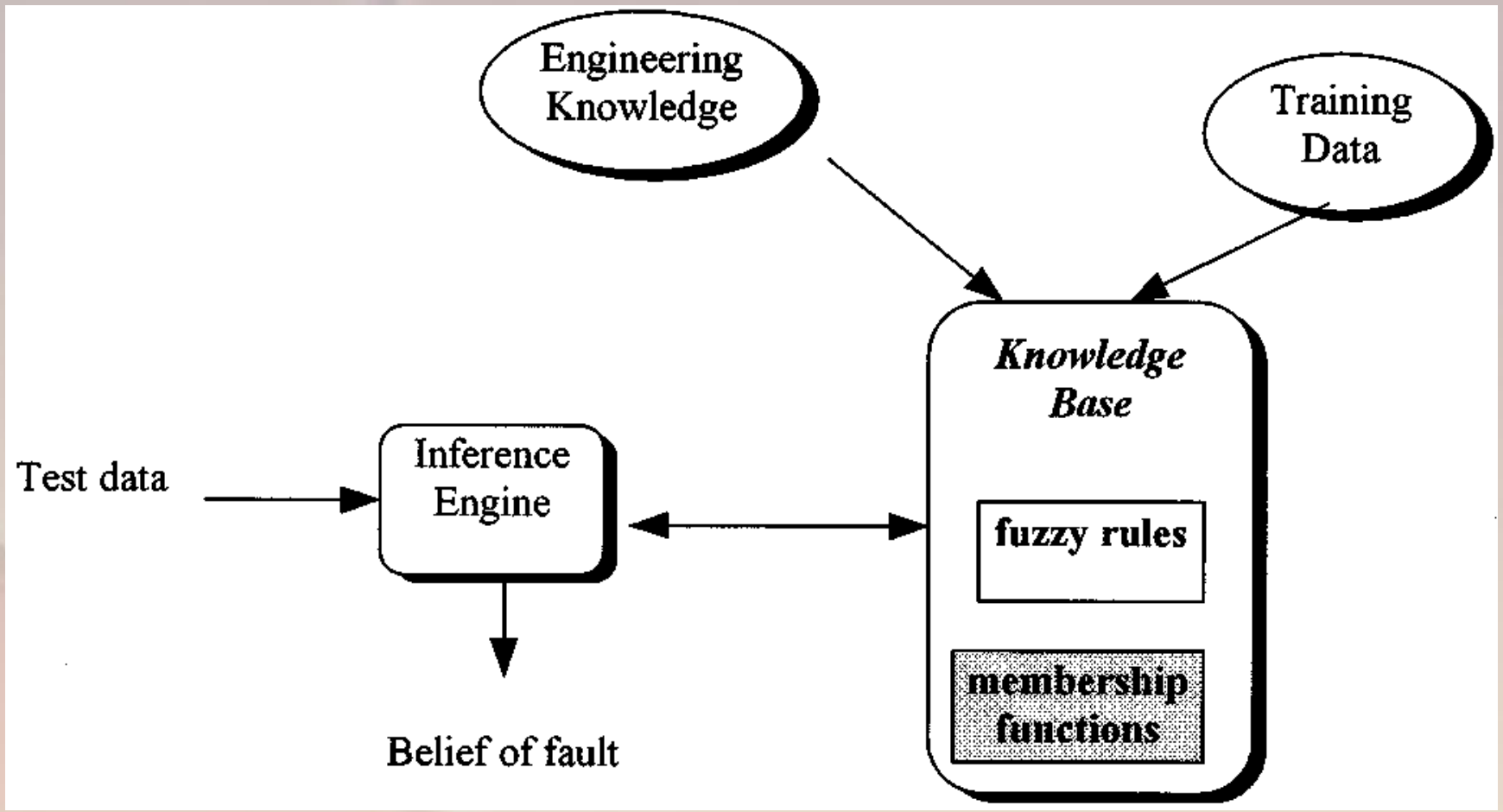
Test signals successfully received

A Fuzzy Diagnostic Model[3]



Reference[3]

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- Yi Lu, Tie Qi Chen, and Brennan Hamilton, A Fuzzy System for Automotive Fault Diagnosis: Fast Rule Generation and Self-Tuning, IEEE Transaction on Vehicular Technology, VOL. 49, NO. 2, March 2000

Implementation of a Fuzzy Model[3]

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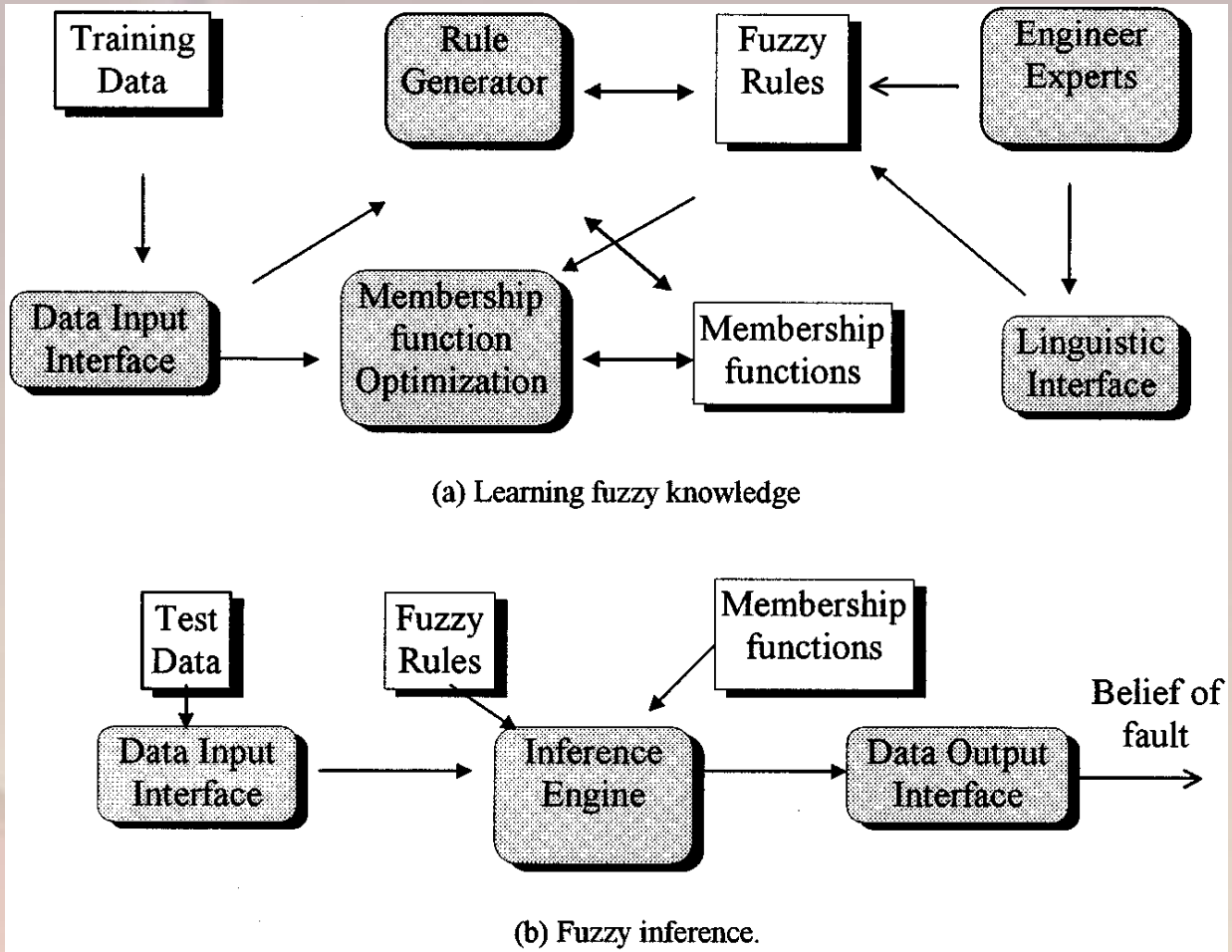

Generating and Refining the Fuzzy Model

- Each membership function is uniquely defined by a set of critical parameters (e.g., 2 for triangles and 4 for trapezoids)
- The rule generator can start with assigning arbitrary initial values to the critical parameters of the membership functions
- Then the input data set is separated into clusters using a cluster-extraction procedure
- After all data have been clustered the locations of cluster centers are calculated. If the locations of the cluster centers don't properly agree with the critical parameters of the corresponding membership functions, the critical parameters are updated

Takagi-Sugeno Type Fuzzy Automaton Block Diagram

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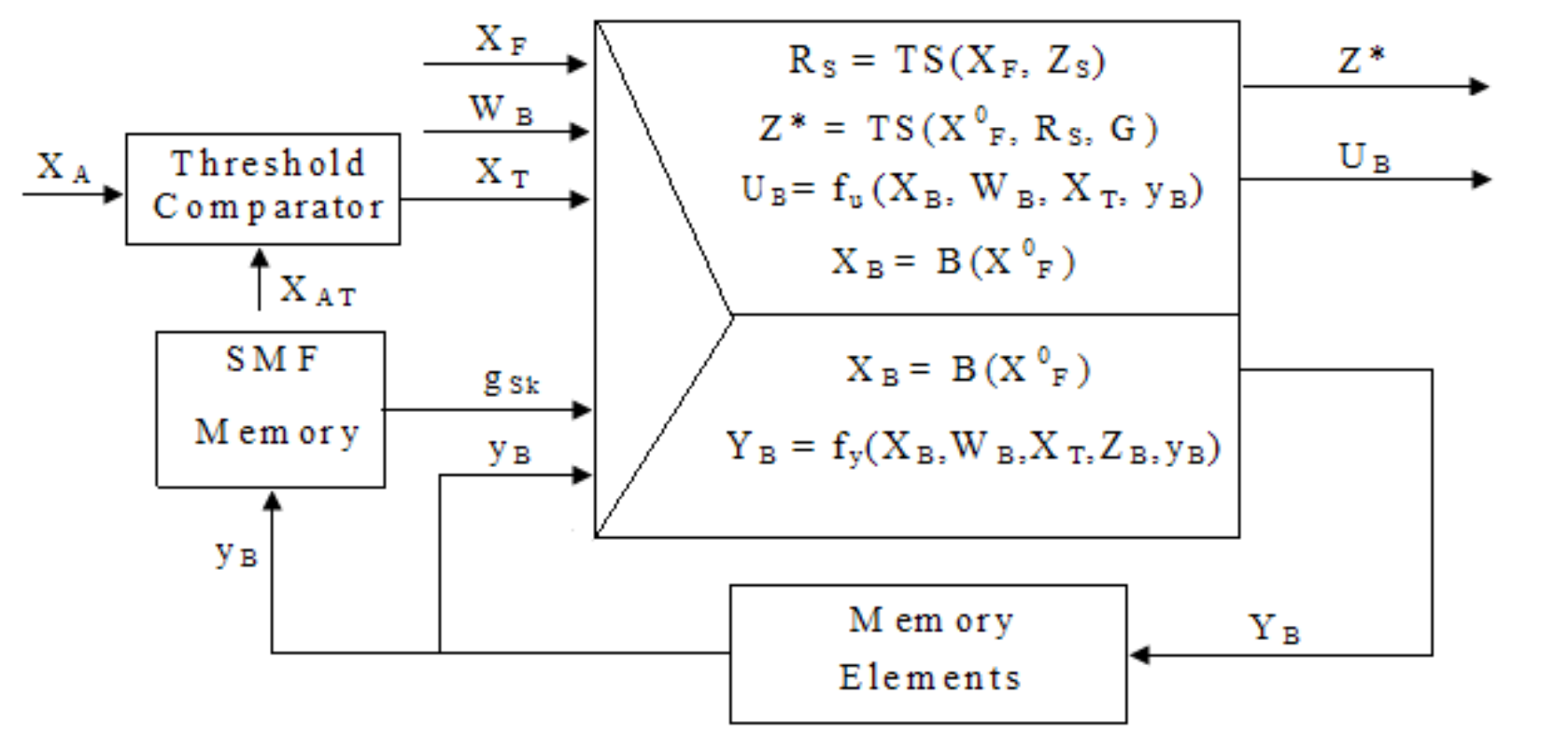

Current Status

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- Engine and WMU Hummer H-1 truck sensor preparation and installation work continuing
- Analog electronics, axle sensors, digital electronics and wireless communication systems have been bread boarded and tested
- Prototype Sensor PCBs
  - axle sensors being populated and tested
  - wireless communications board being populated and tested
  - engine sensing PCB in design phase, awaiting axle PCB results
- Central Module
  - Zigbee to microcontroller to Ethernet to PC path testing completed
- Intelligent diagnostics/prognostics methods
  - Fuzzy logic based approaches being researched
  - Initial fuzzy model for axle being developed